Developing a Better Method of Tag Attachment for Cetaceans

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LONG-TERM GOALS

The goal was to develop and test several novel methods of tag attachments for cetaceans to: (1) increase attachment duration, (2) minimize the negative effects to the individual, and (3) to increase types of tags thus broadening the options for tag deployment and duration of attachment.

OBJECTIVES

The primary goal was to increase the duration of tag attachment while limiting the detrimental effects of placing an anchoring device in or on animals. We proposed to develop and test several novel approaches for attaching instruments to marine mammals, especially large whales. Long-term attachment requires a firm and biocompatible anchor into the animal that causes the least amount of injury and infection and resists the tendency for rejection. The type of tag used is dependent on required duration of attachment, thus a non-invasive suction cup attachment might be used for short-term attachments (e.g. hours to a day), whereas an implanted tag that is invasive might be used for intended attachments of months to years. We proposed a prong with lateral movement (called an anchoring wing) after tag penetration that would be more effective as a deterrent to rejection of implanted tags. The combination of a more secure anchor and a smaller tag will increase the longevity of tag deployments. We also proposed to develop and test minor modifications to suction-cup attachments (i.e. post with barb) that will increase the duration of attachments of instruments via suction cups. Finally, we proposed a barb attachment with external tag that would minimize the implantable portion of the tag while allowing prolonged attachment (e.g. 1 to 4 weeks) beyond that afforded by suction-cup attachments (0 to 2 days). These attachments types would be designed, bench tested, and subsequently tested on stranded cetacean carcasses. Future funding would allow for these various attachment techniques to be tested on free-ranging animals

APPROACH

The first task was a thorough review of the literature and production of an annotated bibliography that would be made available to anyone considering tagging large whales. This 75-pg document will allow others to quickly review the effectiveness of previous tag designs, and allow them access to these papers/reports so they can more efficiently and effectively design new tags. Secondly, we designed and built three types of tags attachments: (1) implantable tag attachment that involves laterally spreading

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"wings", (2) barb attachment with external tag, and (3) suction-cup attachment with external tag. These designs were then tested in the lab and on cetacean carcasses.

SUMMARY OF WORK COMPLETED

The publication review and resultant 75 – page annotated bibliography were completed and are presented elsewhere. Most of the published works in the primary literature and some grey literature were reviewed and the salient points regarding tag design, placement, attachment, and longevity were summarized.

Anchoring wing Attachment

We designed and tested two prototypes of the anchoring wing. The first prototype consisted of two wings that were rotated into position using an electric motor. The second prototype was fabricated using a simpler gear design, resulting in a more compact housing diameter of 20 mm. This transmission used fewer gears, but resulted in the wings rotating in the same direction with less torque. The power mechanism of this unit relies on a torsion spring to drive the transmission and wing deployment (Fig. 1). We believe this unit is the most promising due to its smaller diameter and more reliable power method. This unit does not require a waterproof housing, as would one with an electric gear motor, simplifying fabrication and reliability of the tag. No internal electronics are required, and the spring would be activated on impact.

We tested this device in simulated whale blubber (layers of foam and silicon) and successfully determined that there was adequate torque created by the spring to fully deploy the anchoring wings. We did not have the opportunity to test the anchoring wing deployment in a whale carcass.

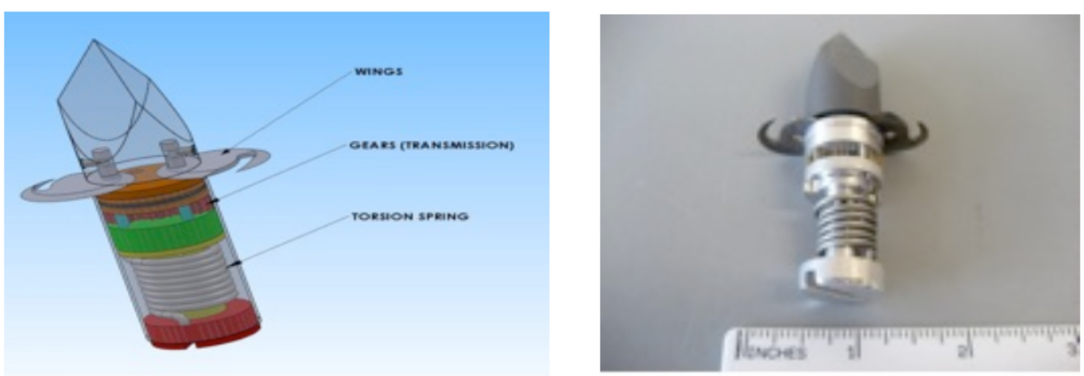
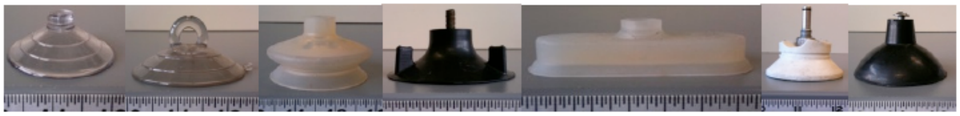


Figure 1. The CAD presentation of the anchoring wing attachment (left image) and the actual prototype without casing (right image). The anchoring wings are shown deployed after a torsion spring via gearing has swung the metal wings perpendicular to the pointed tag tip. The anchoring wing tip would be screwed to the anterior end of an implantable tag.

Suction Cup Attachment

We tested 10 suction cups (Table 1) for vertical and horizontal failure on a rubber and plexiglass surface over a timed interval. Vertical failure tests were conducted on an hourly interval. All suction cups except for types H and I (Fig. 1) failed within one hour, whereas H and I remained attached for > 24 hours (maximum 2.4 days). Suction cup materials that exhibited extreme flexibility or extreme stiffness formed the best long-term seals. In future applications, the use of suction cups H or I are recommended due to their greater horizontal slip / vertical failure points and lesser costs. The use of a single pedal barb was tested on suction cup types E and H. This increased the horizontal slip to 50 lbs, but did not increase the vertical failure point. The use of a prong may stop the suction cup from sliding on the horizontal plane, effectively locking the cup in the desired position. We have developed a full deployment kit for the suction cup pole spear, and are ready for in-field testing on live animals.

Table 1. Diameter and surface area of nine rubber suction cups tested on glass and the holding force (lbs) and slip force (lbs) measured horizontally until failure and the vertical force required until failure for each type of cup.



Cup: A, B, C D E F G H I

CUP TYPE	DIAMETER (mm)	SURFACE AREA (mm^2)	HOLDING FORCE (lbs)	HORIZONTAL SLIP (lbs)	VERTICAL FAILURE (lbs)
A	44.4	1551	25.9	5	20
B	63.5	3167	72.1	9	22
C	76.2	4560	103.9	8	20
D	82.5	5352	141.4	9	34
E	82.5	5352	141.4	12	32
F	92.3	7125	162.3	16	50
H	82.5	5352	141.4	22	24
I	76.2	4560	103.9	50	50

We tested and modified several types of suction cups by adding a small barb embedded in the cups symmetrical to the centerline and protruding below the suction cup's lip. The concept was to provide enough anchoring into the tissue to prevent the cup from slipping horizontally along the animal due to hydrodynamic drag. Ideally, this would provide a deployment time of 1 to 2 weeks instead of a few days. Custom adaptors were machined to fit into a 1.25 cm (1/2 inch) diameter centerline hole, which was drilled through the suction cup. A hole was tapped on one end of the adaptor to allow a variety of barbed tips to be threaded tightly onto the bottom of the suction cup. This design allows for a variety of different barbs to be easily fitted and tested on all suction cup types. Silicon caulking was used to fill the gaps around the drilled hole and the barb adaptor, creating an airtight seal to ensure a solid vacuum. The barb tips were machined from 0.79 cm (5/16 in) x 3.81 cm (1.5 in) stainless steel bolts (Fig 2). A number of different designs were created, including a thin barbed tip with a single petal and a conical pointed barb. The barb protrudes 0.64 cm (1/4 in) past the bottom of the suction cup (Fig. 2). We tested the suction cup with and without a barb on a humpback whale carcass. The addition of a barb did not substantially increase the vertical holding ability, however, it did decrease horizontal slippage. Therefore, the use of a barb on suction cups did not greatly increase performance, however, we believe this needs to be tested on free-swimming whales to adequately test its effectiveness.

Figure 2. Flexible latex suction cup built by Cetacean Research Corp. and modified with a 0.64 cm barb with conical pointed barb (left image), and field testing vertical holding strength of a suction cup (type I) tag with barb on a stranded humpback whale (right image).

We have completed all of the objectives of our first year of funding, as outlined in the original proposal. We completed the literature review. We have designed and built prototypes of suction cups with prongs and implantable tags with anchoring wings, and tested them in the lab (e.g. aerodynamics and imbedding. We are proposing to build functioning tags, that is purchase and encapsulate the electronics (VHF/UHF) incorporate the anchoring wings, and then test their durability and duration of attachment on free-swimming large whales off central California.

We seek funding for a second year to further develop and test these concepts. In particular, we will continue to field-test various barbs and suction cup designs on large whales off central California. We will assess the duration of attachment, data recovery, and effects on the animal by tracking the animal in real-time for as long as possible, recovering the device once detached, and photographing the deployment and animal before and after tag placement to investigate the effects of tagging. Tagging operations will start in late summer or fall under NMFS permits issued to myself (NMFS Research Permit No. 15271 issued 25 March 2011) or under permits to John Calambokidis (Permit No. 540-1811-03).

RELATED PROJECTS

We also sponsored a workshop of whale tagging experts at MLML on 16 March 2009, and the summary of those discussions were completed and distributed to participants.

Invitees:

John Calamabokidis (Cascadia Research Collective – Tacoma WA)
Dave Casper (veterinarian – UC Santa Cruz, Santa Cruz CA)
Frances Gulland (veterinarian – The Marine Mammal Center – Sausalito CA)
Jim Harvey (Moss Landing Marine Laboratories – Moss Landing CA)
Mads Peter Heide-Jorgensen (Denmark)
Bruce Mate (Oregon State University – Newport OR)
Mike Weise (ONR – Arlington VA) – Mike by phone (weather did him in)
Alex Zerbini (National Marine Fisheries Service – Seattle WA)

Funds from this project were used to support the travel of a few project participants. Topics of discussion included:

1. General discussion of current tags and techniques being used by participants
2. Specific topics:
    Tip design and cutting, wound healing, use of antibiotics
    Anchor design, housing materials, and performance
    Force of delivery, Encapsulation or not
    Antenna wobble, Tag movement (antenna mountings)